

CLAIMS

1. A method of treatment of water containing dissolved solids, wherein the water is selected from the group consisting of types 1 to 7 waters as defined in Table 1:

TABLE 1

Type	TDS (g/L)	Cl/HCO ₃ ⁻ mol.	Cl/2SO ₄ ²⁻ mol.
1	1 to 60	<2	>1
2	1 to 15	≥2	>1
3	1 to 15	>2	<1
4	> 15, ≤60	>5	>7
5	> 15, ≤60	>5	<7
6	>60	>5	>9
7	>60	>5	<9

comprising the steps of:

- (a) contacting the said water with a first reagent comprising a source of calcium ions selected from the group consisting of calcium oxide, calcium hydroxide, and a combination thereof, so as to cause at least some solids dissolved in the water to react with the first reagent and to form a first solid product and a partially processed water wherein, in the event that the water containing dissolved solids is a Type 1 water, the first solid product is precipitated calcium carbonate (PCC) and, in the event that the water containing dissolved solids is a water of any of Types 2 to 7, the first solid product is gypsum-magnesium hydroxide mixture (GMH) and wherein the said GMH is further treated by the addition of sulphuric acid to react with 5-50% of the stoichiometric amount of magnesium hydroxide present in the GMH;
- (b) recovering the first solid product from the partially processed water;

- (c) at least partially concentrating the partially processed water or a portion thereof, so as to promote the formation of a precipitate and a mother liquor; and
- (d) recovering the precipitate from the mother liquor as a second product.
- 5 2. A process as claimed in claim 1, wherein the water is a type 1 water having a salinity of from 1 to 50 g/L TDS.
3. A process as claimed in claim 1, wherein the water is a type 1 water having a salinity of from 1 to 40 g/L TDS.
4. A process as claimed in claim 1, wherein the water is a type 1 water having a salinity of from 1 to 30 g/L TDS.
- 10 5. A process as claimed in claim 1, wherein the water is contacted with a predetermined amount of the first reagent.
6. A process as claimed in claim 1, wherein the water is a water of type 1 and the first product is precipitated calcium carbonate (PCC).
- 15 7. A process as claimed in claim 1, wherein the water is a water of type 1 and the second product is sodium hydroxide.
8. A process as claimed in claim 1, wherein the water is a water of any one of types 2, 4, 5, 6 and 7, and the second product is sodium chloride.
9. A process as claimed in claim 1, wherein the water is a water of type 3, and the second product is sodium sulphate.
- 20 10. A process as claimed in claim 8, wherein, after step (b), the partially processed water is contacted, in a step (e), with a second reagent also comprising a source of calcium ions selected from the group consisting of calcium oxide, calcium hydroxide, and a combination thereof, so as to cause at least some of the solids dissolved in the partially processed water to react with the second reagent and to form magnesium hydroxide, and wherein the magnesium hydroxide is recovered from the partially processed water before the recovery of said sodium chloride therefrom.
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11. A process as claimed in claim 1, wherein the water is a water of type 1 and the pH of the partially processed water is reduced, in a step (b)(i), to a pH falling within the range of from 7 to 10.
12. A process as claimed in claim 11, wherein the pH of the partially processed water is reduced by adding to the partially processed water a pH reducing agent selected from the group consisting of hydrochloric acid, sulphuric acid, saline impaired feed water, an RO concentrate of type 1 water, and a combination of any two or more thereof.
13. A process as claimed in claim 11, wherein the water is a type 1 water, the pH of the partially processed water is reduced to between 8 and 9 by adding sulphuric acid to the partially processed water and wherein the second product is sodium sulphate.
14. A process as claimed in claim 11, wherein the water is a type 1 water, the pH of the partially processed water is reduced to between 8 and 9 by adding hydrochloric acid to the partially processed water and wherein the second product is sodium chloride.
15. A process as claimed in claim 11, wherein the water is a type 1 water, the pH of the partially processed water is reduced to between 8 and 9 by adding diverted water to the partially processed water and wherein the second product is sodium carbonate.
16. A process as claimed in claim 6, wherein the first reagent is hydrated lime slurry and the weighted average sulphate ion concentration of the water and the hydrated lime slurry is controlled below 3 g/L.
17. A process as claimed in claim 16, wherein the weighted average sulphate ion concentration is controlled by controlling the volume of hydrated lime slurry contacted with the water or by controlling the concentration of solids in the hydrated lime slurry, or by both.
18. A process as claimed in claim 1, wherein the reacted GMH product is dried at a temperature between 120°C and 300°C.

19. A process as claimed in claim 1, wherein the water to the process is a type 4 or a type 6 water, wherein, after step (b), sodium carbonate is added to the partially processed water, and wherein magnesium carbonate light (MCL) is recovered therefrom to produce a treated water which is low in magnesium content.
- 5 20. Use of the treated water produced by the process of claim 19 in a cyanide based leach process.
21. A process as claimed in claim 6, wherein, in step (a), only a portion of the bicarbonate ions in the water are converted to PCC and, wherein, in a secondary reaction step, the first solid product and the partially processed water of step (a) are contacted with a solution of calcium chloride to convert substantially all of the carbonate ions in the partially processed water to PCC.
- 10 22. A process as claimed in claim 6, wherein, in step (a), only a portion of the bicarbonate ions in the water are converted to PCC and, wherein, in a secondary reaction step after the recovery of the said PCC in step (b), the partially processed water of step (b) is contacted with a solution of calcium chloride to convert substantially all of the remainder of the carbonate ions in the partially processed water to supplementary PCC.
- 15 23. Use of magnesium hydroxide recovered from the process as claimed in claims 10 or 17 to pre-condition water to an RO desalination plant.
- 20 24. A process as claimed in claim 1, wherein the water is or comprises a concentrate from an RO desalination plant.
25. A process as claimed in claim 1, wherein a portion of the mother liquor of step (d) is combined with the partially processed water from step (b) before it is subjected to evaporation in step (c).
- 25 26. A process as claimed in claim 1 or claim 25, wherein a portion of the mother liquor of step (d) is evaporated to total dryness.
27. An apparatus for the treatment of water containing dissolved solids, wherein the water is selected from the group consisting of types 1 to 7 waters, as defined in Table 1:

TABLE 1

Type	TDS (g/L)	Cl ⁻ /HCO ₃ ⁻ mol.	Cl ⁻ /2SO ₄ ²⁻ mol.
1	1 to 60	<2	>1
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5	> 15, ≤60	>5	<7
6	>60	>5	>9
7	>60	>5	<9

comprising:

- (A) means for contacting the said water with a first reagent comprising a source of calcium ions selected from the group consisting of calcium oxide, calcium hydroxide, and a combination thereof, so as to cause at least some of the dissolved solids to react with the first reagent and to form a first solid product and a partially processed water; wherein, in the event that the water containing dissolved solids is a Type 1 water, the first solid product is precipitated calcium carbonate (PCC) and, in the event that the water containing dissolved solids is a water of any of Types 2 to 7, the first solid product is gypsum-magnesium hydroxide mixture (GMH) and wherein the GMH is further treated by the addition of sulphuric acid to react with 5-50% of the stoichiometric amount of magnesium hydroxide present in the GMH;
- (B) means for recovering the first solid product from the partially processed water;
- (C) means for at least partially concentrating at least a portion of the partially processed water, so as to promote the formation of a precipitate and a mother liquor; and

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(D) means for recovering the precipitate from the mother liquor as a second product.

28. An apparatus as claimed in claim 27, wherein the means (A) comprises a train of up to three mixed reactors.
- 5 29. An apparatus as claimed in claim 27, also comprising a washing unit selected from a counter current washing unit and a co-current washing unit, for washing the first product after recovery thereof.
30. An apparatus as claimed in claim 27, also comprising an RO desalination plant, and wherein the desalination plant produces a permeate which has a low
10 concentration of dissolved solids and a concentrate which has a high concentration of dissolved solids, and wherein the concentrate is fed to the means (A).
31. An apparatus as claimed in claim 27, also comprising a break tank for stripping dissolved methane gas from the feed water.
- 15 32. An apparatus as claimed in claim 27, also comprising a lime slaker for preparing lime slurry for use in the means (A).
33. An apparatus as claimed in claim 27, wherein the means for at least partially concentrating is an enhanced solar evaporation system, comprising:
20 -means for pre-concentrating the dissolved substance by evaporating a portion of the water from the solution so as to form a concentrated solution;
-a container for holding the concentrated solution and for absorbing solar energy so as to cause the temperature of the concentrated solution to rise; and
-evaporation means for causing water to evaporate from the concentrated
25 solution..
34. An apparatus as claimed in claim 33, also comprising a crystalliser for causing the dissolved substance to precipitate from the concentrated solution after water has been evaporated from the concentrated solution in the evaporation means.

35. A process for treating a saline process water in a gold mining operation comprising the steps of adding a lime slurry [$\text{Ca}(\text{OH})_2$] first under fast and then under slow mixing conditions to form a slurry, which slurry is then washed and dewatered to produce a compound of desired thickness, comprised of $\text{Mg}(\text{OH})_2$ and CaCO_3 minerals, and storing and aging the spent water to mature by aeration, which solution can then be fed directly to a CIL circuit.
36. A process for the manufacture of PCC compounds from mildly saline waters of surface or ground water origin, comprising:
- (a) if required, pre-concentration of the raw ground water solution by natural evaporation or artificial means, to adjust bicarbonate (HCO_3) ion concentration in the solution to between 1g/L and 15g/L HCO_3 ;
 - (b) reaction of the said raw ground water or pretreated feed solution with hydrated lime slurry, under constant stirring conditions, at temperatures 30°C or higher, to allow formation of a slurry due to nucleation of fine grain calcium carbonate crystals;
 - (c) transfer of the slurry to a solids/liquid separation vessel to allow proportional removal of the decarbonated supernatant (spent water) to a neutralisation vessel, followed by pH adjustment to around pH 7 by adding acid, and re-use or disposal of the resultant neutralised water;
 - (d) transfer of the slurry to a wash thickener vessel, washing the slurry first with fresh water to remove excess dissolved salts, followed by thickening to obtain a precipitated calcium carbonate slurry product;
 - (e) optionally and depending on market requirements, further dewatering of the precipitated calcium carbonate slurry product (in "d") to obtain a cake, which is dried and powdered to obtain a precipitated calcium carbonate powder product.